DOCUMENT RESUME

ED 348 035 IR 015 772

AUTHOR Ullmer, Eldon J.
TITLE Learning Environments; The Technology-Cognition Connection.
PUB DATE Feb 92
NOTE 10p.; In: Proceedings of Selected Research and Development Presentations at the Convention of the Association for Educational Communications and Technology and Sponsored by the Research and Theory Division; see IR 015 706.
PUB TYPE Information Analyses (070) -- Viewpoints (Opinion/Position Papers, Essays, etc.) (120) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Computer Assisted Instruction; Computer Simulation; Computer Software Development; Courseware; *Educational Technology; *Instructional Design; *Instructional Development; *Learning Processes; *Learning Theories; Literature Reviews; Man Machine Systems; Models
IDENTIFIERS *Learning Environments

ABSTRACT

This paper considers the technological aspects of learning environment analysis in the instructional development process. Characteristics of a technology-based learning environment are discussed, and old and new models of technology and learning are examined. The connection between technology and cognition is addressed, and the importance of design of learning environments that take into account the following considerations is emphasized: (1) principles of human factors, especially human-computer interaction; (2) learner involvement strategies; (3) the situated nature of learning (i.e., the idea that knowledge is a product of context, activity, and culture, and that environments structure cognition); and (4) the problem of providing authentic learning situations. (16 references) (MES)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

ED348035

Title:

Learning Environments: The Technology-Cognition Connection

Author:

Eldon J. Ullmer

1205772

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Michael Simonson

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

BEST COPY AVAILABLE

LEARNING ENVIRONMENTS: THE TECHNOLOGY-COGNITION CONNECTION

Eldon J. Ullmer

Introduction: Perceptions of the Learning Environment

This session's common theme is that including an "environment analysis" in the instructional development process will improve learning system design. My task is to discuss the technology aspects of such an analysis; however, what this analysis should include is far from obvious. Clearly there are several possible views regarding the environment's role in learning: One, that it is neutral; two, that it is a relevant but ancillary factor; and three, that the environment is an active element in the learning process. Adopting the first attitude allows the instructional designer to ignore the environment. Adopting the second mainly means documenting those aspects of the environment that might adversely affect use of an instructional product in a given setting. Adopting the third view means recognizing the environment as part of the technology-strategy-activity nexus that all teaching involves.

I expect that some might hold that the environment is neutral with respect to learning; after all, some have argued that media do not influence learning, that they are mere information carriers. Kozma (1991, p. 205) argued that this conclusion was faulty because it did not take into account the "cognitively relevant characteristics" of media. Time does not permit discussion of this issue here; the important point is that just as a medium is more than a neutral vehicle, a learning environment is more than a neutral setting or locale.

But accepting that principle still leaves another question: Is the environment simply an ancillary factor in instructional design, or might an environment, like a medium, possess "cognitively relevant characteristics" that are, therefore, integral design factors? The way this question is answered obviously affects the ID process; therefore this inquiry focuses on two primary questions: 1) What is the case for the premise that technological learning environments are "active agents" in the learning process?, and 2) What are the design implications of accepting this premise?

Aspects of A Technology-Based Learning Environment

An advertisement for an imaging system being marketed by a major computer firm proclaimed that it was "not just a collection of graphics tools but a total working visualization environment." Tay Vaughn (1988) defined the idea of a computer "environment," saying that the term refers to "a set of rules, conditions and capabilities within which programs can be created and then run." The twin-points here are 1), a technological environment is more than an array of tools, it is a working, function-related, integrated system; and 2), that while a such a system may afford users superb capabilities, it also sets creative limits and imposes its particular rules and regimens on the user.

Kosma (1991), in his review of media research, distinguished between the learner's internal and external environments, and presented an image of the learner using his or her internal cognitive resources to manage the extraction of information from the external environment to built new knowledge. This presents a markedly different view of the learning process from the one on which the "media-are-mere-vehicles" conclusion was based. Also, it reminds instructional developers that anything that affects information acquisition and use is an active element of the learner's "external environment."

John Sculley (1991) provided an interesting perspective on learning environments while addressing the problem that although modern technology has greatly improved information processing capabilities, white collar productivity has not similarly improved, either in schools or in the workplace. Sculley said this was because "new technology has been mapped on top of an old work model and an old learning model." In the broadest sense, then, an instructional environment is what results from mapping a technology model on top of a learning model. Every learning environment thus embodies what Martin Tessmer calls a "technology culture" comprised of the available technology, the attitudes and expertise of the learners and teachers who will use it, and their perceptions of how it ought to be used to facilitate learning. Thus it is reasonable to conclude that learning environments do possess "cognitively relevant characteristics" that must be addressed during design.

The environment and learning question, then, breaks down into three related questions: What is the "new" technology model? What is the "new" education model that technology is supposed to implement? And, how should they be connected? Examining the old models will facilitate understanding the new models.

The "Old" Technology Model

A technology model embodies two complementary ideas--an image of tool-use that links device and user in purposeful activity, and an image of some functional goal that puts the "purpose" in that activity. For centuries, the printed page has been the basic tool for managing information, and Sculley says that even through the 1980s it remained as the "computing metaphor for documents." Early in this century, Thorndike provided a "big idea" about using the print medium as an instructional technology when he wished for a device that would not allow the student to go to page two until he mastered what was on page one. No one did much with that idea for a long time, but this image of tool-use remained until it emerged in the 1960s as the essential idea underpinning programmed instruction.
Although programmed instruction as a media form did not last, the basic notions that came out of that tradition remain at the center of today's dominant instructional paradigm. I call it the tools and tasks paradigm because it invokes a particular image of media use and teaching: The basic learning environment is the classroom; the teacher controls the use of technology; the learner is subordinate to the teacher; media are regarded as simple delivery tools; the objective is assimilation; and the value that drives evaluation is efficiency.

The "Old" Learning Model

Sometime after Thorndike offered his suggestion for a model teaching tool, another big idea, attributed to Frederick Taylor, took hold. This was the mass production-based "factory model" which, Sculley (1991) says, separated planning from doing and reduced the worker's role, thus minimizing the knowledge and skill required. Education's didactic form reflected this model, and didactic instruction, though widely criticized, remains the dominant form of teaching. Its deficits have been cataloged by Brown, Collins and Duguid (1989), among others: Knowledge is viewed as a quantity of abstract, self-contained facts and concepts to be "delivered" to the learner. The context of learning is thought to be "merely ancillary" to the learning process and no serious thought is given to how the learning situation might affect cognition or to how to make learning activities "authentic." Thus knowledge is separated from its environment-of-origin and no link between learning and use is formed. Consequently,

success in the school setting does not ensure success in an application setting where problems are not always well-defined, nor solutions always clear-cut.

The "New" Technology Model

Over a decade ago Manfred Kochen (1981) saw the convergence of computers and communications as a new technology in the making (p. 148). Since then, powerful personal computers have become ubiquitous, optical disc systems, fiber optics and networking technology have all advanced enormously. Computer-controlled, optical disc systems epitomize the new technology. Such systems easily surpass older media in technical capabilities and also hold much potential for changing the learning process. This potential will be lost, however, if the technology is used with a deficient learning model.

The "New" Learning Model

While there is no definitive "new" learning model, several presently emerging themes illustrate a new line of thinking about instruction. One of these themes, as explained by Brown, Collins and Duguid (1989), is called "situated cognition." This idea challenges the notion that the environment or situation in which learning occurs is "neutral" or "ancillary" and argues that knowledge is a product of context, activity and culture (p. 42), that learning and cognition "are fundamentally situated." They see conceptual knowledge not as an abstract entity but as a tool, and argue that just as one acquires skill in using a tool through engagement in "authentic activities" in real-world situations, conceptual knowledge should be developed through student work that reflects what practitioners in the domain actually do.

A major design idea of the situated cognition perspective is that problem solving tasks should be staged so that a solution is reached not just by rote processing but by means that enable the learner to use the environment to solve the problem, means that are said to be "in conjunction with the environment" (Brown, Collins and Duguid, 1989, p. 35).

A related idea called "anchored instruction" is under study by The Cognition and Technology Group at Vanderbilt (1991). This group is doing research on "the effects of situating instruction in videodisc-based, problem solving environments" (p. 2) which are intended to permit students to engage in "sustained exploration" of a problem from "multiple perspectives" (p. 3).

In another context, Rappaport and Halevi (1991, p. 69) offer an interesting thesis about the computer industry when they predict that by the year 2000, "the most successful computer companies will be those that buy computers rather than build them." As a current example, they cite Microsoft, a company that does not manufacture computers, but, as the leading developer of microcomputer software, has become more successful than anyone who does. What does that have to do with instructional development? The essential idea is that the software that Microsoft makes does more than merely allow computers to run, it defines the "desktop computing environment" (p. 72), and the nature and value of computing. Likewise, good instructional design does more than merely use computers and media well, it defines the learning environment's value and utility. Sculley (1991), speaking about productivity generally, says: "The real challenge for developers will be to create products based on emerging technologies that reflect the changing way that people work in an information

economy (p. 9). Instructional developers, I believe, could adopt this challenge without changing a word.

Forging the Technology-Cognition Connection

As the problem of finding powerful technology to apply to instructional problems becomes secondary to learning how to use that technology to achieve the larger goals of reorganizing work and learning, successful instructional development will require added emphasis on the design of learning environments that take into account: One, principles of "human factors," especially human-computer interaction; two, learner involvement strategies; three, the "situated nature" of learning, and four, the problem of providing "authentic" learning situations.

Human Factors

Human factors considerations relate to environment analysis at several levels. Ergonomics deals with the physical aspects of using technical devices. But human factors also must address those human capabilities and limitations that affect cognition and learning (Staggers, 1991, p. 47).

Some very useful ideas on the application of human factors to instructional development are to be found in a recent paper by Orey and Jih (1991). They contend that the nature of interaction between computers and human users is a "neglected area" of study, and they list several techniques now being explored to facilitate employing human factors in instructional design. These include adaptive interfaces, task analysis, measuring user's mental models, design audits, mock-ups, prototyping, and field trials.
All are intended to make human-computer interaction effective and "user-friendly," based on the awareness that in any setting, student populations will include people who possess vastly different skill in using computers.

Perhaps the most interesting element in their paper is a chart that relates human factors guidelines to each of Gagne's nine events of instruction, a widely-used construct in instructional development.

There is one research study with human factors elements that I find very interesting. An English professor at the University of Delaware, Marcia Peoples Halio, did a five-year study in which she compared the quality of student papers produced on Macintosh and MS-DOS machines. As reported in the Washington Post by T. R. Reid (1991), she found that DOS users produced papers with much higher readability scales and with far fewer spelling errors. Moreover, she also noted that DOS users were more likely to write about serious issues, such as war and pollution, while MAC users wrote about such topics as fast food.

The big question, of course, is, what does this mean? Reid's conclusion was simple: "Mac people" are different from "DOS people." IBM people, he says are "no-nonsense" types who follow established ways of doing things while Mac people are "free spirits" and "artistic types" who worry less about rules of grammar and spelling. Thus if "Mac people" are seen as a more creative lot and "DOS people" as a more serious group, it is interesting to speculate what will happen as the Mac becomes more like an IBM-PC and DOS-PCs adopt Macintosh-like user interfaces.

Learner Involvement

Implicit in any learning environment design is a particular "image of the learner" (Ullmer, 1989) that defines how the learner is expected to use that environment. One such "image" is what Alan Kay (1991, p. 138) calls the "fluidic theory of education" which holds that students are "empty vessels" to which knowledge is to be transferred "drop-by-drop." The notion that media are mere delivery vehicles draws heavily on this image. Not surprisingly, Kosma's (1991, p. 179) analysis of media research is based on an entirely different image--that of a learner "actively collaborating" with the environment "to construct knowledge," and strategically managing his or her "cognitive resources" to create new knowledge.

James Dezell (1988, p. 10) of IBM says that technology-based learning environments should be "responsive to the ways today's children receive information" and that these environments should be "programmed for discovery rather than instruction."

Kay (1991, p. 138) picks up on the same theme but carries it a bit further. He believes that powerful, networked computers can greatly enhance learning, "but only in an educational environment that encourages students to question facts and seek challenges," to not accept everything at face value. He agrees with Jerome Bruner that people can devise for themselves new ways of thinking and thus expand their understandings.

Situated Learning

The main idea behind situated learning, to repeat, is that environments structure cognition, that situation, activity and culture co-produce knowledge.

Kosma (1991, p. 180) holds that the learning process is "sensitive to characteristics of the external environment such as the availability of specific information at a given moment, the duration of that availability, the way the information is structured, and the ease with which it can be searched." Thus these become important design consideration with regard to mediating instruction in any learning environment.

Brown, Collins and Duguid (1989) provide a very interesting example, drawn from Lave's work, of how a situation can help structure cognition. The example is from a Weight Watchers class and the problem was how to create a cottage cheese serving that equalled three-fourths of the two-thirds cup that the program allowed. They relate how the problem solver paused to size-up the situation, then suddenly proceeded to fill a measuring cup two-thirds full, dumped it onto a cutting board, patted it into a circle, marked a cross on it, removed one quadrant, and served the rest. This is problem solving carried out "in conjunction with the environment."

Authentic Situations

Alan Kay (1991, p. 138) relates an observation by physicist Murray Gell-Mann that compares modern education to being taken to a fine restaurant and being fed the menu. He meant that students are taught in a superficial manner in which representations of ideas replace the ideas themselves. Technology will soon provide students with computerized access to massive data resources. The critical design question, Kay says, is how to get from the menu to the food. Put another way, how can designers create the authentic environments that enable students to acquire meaningful, usable knowledge?

The example of the Weight Watchers class illustrates the value of providing an authentic situation in which problem solving is carried out in conjunction with the environment. But obviously teachers cannot issue cottage cheese and other needed items to everyone studying fractions. Nor can medical students be given open use of laboratories and expensive diagnostic equipment and be issued a patient with a designated illness. This is where technology is most useful--in providing realistic simulations of the types of problems that practitioners actually encounter. But designers have to be able to recognize the key elements of the environment to be simulated.

One excellent example of such a simulation is the National Board of Medical Examiners Computer Based Testing or CBX program. The program includes several case simulations in each of several medical areas. A case might begin with a patient in an emergency room. The student user takes a patient history and does a physical exam of varying completeness depending on the urgency of the problem. The user then prescribes appropriate therapeutic measures. The program is realistic in that the user, to obtain the results of tests ordered, must advance the "clock," and, as the clock advances, the disease also progresses. As laboratory results are returned, the user adjusts the treatment regimen as deemed appropriate. Once the course of the patient has been established and the simulation ends, the user receives a list of procedures ordered correctly, those ordered unnecessarily, and decisions made that were harmful to the patient (Wilkes, 1990).

Numerous other simulations that employ similar principles are presently being used in health sciences education and educators are gaining experience in their design, and in discovering the basic requirements of good design.

Dertouzos (1991) provides an interesting way of looking at specifying design requirements for information technologies. To escape "the present chaos" regarding computer-based networks, and to fashion them into "a true information infrastructure," he says networks must have three key capabilities: flexible information transport capabilities, common services and common communications conventions" (p. 65). Because computer network users have varying needs regarding transmission speed, reliability and security, and because it is expensive to maximize all three, Dertouzos suggests, metaphorically, that it would be ideal if users could set "levers" to receive the desired level of each capability as needed. Now speed, security and reliability are important in instructional systems, too, but other design factors may be more important in creating authentic learning environments.

The question is: What are they? What "levers" does a designer need to set to maximize the effectiveness of an instructional program?

Two levers are relevant to specifying the nature of the problem: one to make the simple-to-complex setting, and one to make the fixed-solution to open-solution setting.

Two levers also are needed to set situation authenticity. Clyman (1991) outlined several assumptions that underpin the design of the CBX system discussed earlier. One is that the system will provide the degree of realism needed to elicit the behavior of interest from the student, and the second is that the system will "capture those behaviors" in a form that reasonably represents those behaviors. So one lever varies the degree of realism the problem presentation provides, the second addresses the problem of capturing what the student really wants to do.

Kay (1991) offered an interesting insight on what he considers "a well-conceived environment for learning." It should "be contentious, even disturbing," it should "seek

contrasts rather than absolutes, aim for quality over quantity, and acknowledge the need for will and effort" (p. 140). This identifies two additional levers: one to set the degree of contentiousness, and the second to adjust the balance between knowledge quality and quantity.

An observation about the new software form called "groupware" provided another example in which a personality trait was attributed to a computer system. Because some users resented the high degree of control, a software program was redesigned to be "less strident." This suggests another lever to adjust the stridency level of a teaching program.

Any simulation design will likely involve these basic assumptions and problems. Instructional developers are taught well to follow rational design models. But building an ideal learning environment arguably requires something more--in applying human factors, and in setting the "levers" of design.

References

Brown, J., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. Educational Researcher, 18(1), 32-42.

Clyman, S. (1991, November). Continued research on computer-based testing. Paper presented at the annual Symposium on Computer Applications in Medical Care, Washington, D.C.

Dertouzos, M. (1991, September). Communications, computers and networks. Scientific American, pp.62-69.

Dezell, J. (1988). A new age in education. T.H.E. Journal (IBM PCs and Compatibles Special Issue.

Kay, A. (1991, September) Computers, networks and education. Scientific American, pp. 138-148.

Kochen, M. (1981). Technology and communication in the future. Journal of the American Society for Information Science, 32, 148-157.

Kosma, R. (1991). Learning with media. Review of Educational Research, 61, 179-211.

Orey, M., & Jih, J. (1991, November). The application of human factors to the ID processes for computer-based programs. Paper presented at the annual meeting of the Association for the Development of Computer-Based Instructional Systems, St. Louis, MO.

Rappaport, A., & Halevi, S. (1991, July-August). The computerless computer company. Harvard Business Review, pp. 69-80.

Reid, T.R. (1991). In college, Mac doesn't always make the grade. The Washington Post (edition unknown).

Sculley, J. (1991, Spring). A road map for the 1990's. Macintosh Development Services Directory.

The Cognition and Technology Group at Vanderbilt. (1990). Anchored instruction and its relationship to situated cognition. Educational Researcher, 19(6), 2-9.

Staggers, N. (1991). Human factors: The missing element in computer technology. Computers in Nursing, 9(2), 47-49.

Ullmer, E. (1989). High-tech instructional development: It's the thought that counts. Educational Technology Research and Development, 37, 95-101.

Vaughn, T. (1988). Using hypercard. Carmel, IN: Que Corporation.

Wilkes, A. (1990, September). Review: Computer based testing--the CBX cases. Medibytes, p. 6.

84

11